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Effect of replacing dietary fish meal or soybean meal with shrimp waste meal on the performance of laying hens

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Abstract

One hundred and forty-four (144) 45 week old laying hens of Black Nera strain were used in an experiment to determine the effect of replacing dietary fish meal (FM) or soybean meal (SBM) with shrimp waste meal (SWM) on the performance of laying birds. The birds were randomly allocated to three groups of 48 birds each. Each group was further divided into four replicates of twelve (12) birds each. Three iso-proteinous and iso-caloric diets were formulated such that a practical layer diet which served as the control diet (diet 1) contained soybean meal (SBM) and fishmeal (FM) as the major protein sources. In diet 2, the FM in the control diet (25gkg^{-1}) was replaced by SWM (40.4gkg^{-1}) (protein for protein), while SWM (201.5gkg^{-1}) was made to replace the SBM (180gkg^{-1}) in the control diet (protein for protein) in diet 3. The birds were given feed and water ad libitum. The experiment lasted 10 weeks. The performance in terms of feed intake, hen-day production, egg number and efficiency of egg production (i.e. dozen egg per kg feed) indicated that birds on diet 2 (SWM/SBM) performed equally well as those in the control diet. Performance was however significantly (P<0.05) reduced when SWM replaced the protein supplied by SBM in which case about 20% of SWM was employed. There were no significant differences in the albumen height, shell thickness, egg shape index and haugh units of eggs produced. Birds on diet 3 however had the lowest (P<0.05) values of egg weight, egg length, egg breadth and the weights of yolk and albumen. Results of this study showed that shrimp waste-meal at minimal level (4%) can successfully replace fishmeal in a practical layers diet without negatively affecting performance or egg quality of the birds. However, replacing 180g SBM/kg with 201.5g SWM/kg diet had detrimental effect on performance probably because of the high level of SWM that was employed.

Keywords: Shrimp waste meal, laying hens.

Introduction

Shrimp waste consists of head, tail, appendages and exoskeleton of shrimp being packaged for local and export market. Significant amount of this waste is generated by the shrimp processing industry because of the large percentage of solid waste components listed above and soluble components lost during the various processing operations. Shrimp farmers produced a record crop in 1990, a total of 637,000 metric tons of shrimp, up by 12% from the previous year (Nigeria Agrovet News, 1994). Shrimp waste meal (SWM) has generated a lot of interests as a protein source of very high potentials for poultry and pig feeding. Fanimo *et al.* (1996) reported that SWM was a good substitute for fish meal in broiler rations and can be included in such rations to replace up to 66% of fish meal (FM) without a significant effect on performance and carcass quality. The same level of substitution of SWM was found to be adequate for weaner pigs (Fanimo and Oduguwa, 1999).

The utilization of SWM as animal feed resources is limited because of the presence of chitin, which is abundant in the exoskeleton of shrimp. Chitin is a homoglycan containing glucosamine being a linear polymer of acetyl D-glucosamine joined together by β 1-4 linkages (McDonald *et al.*, 1991). Chitin forms part of the protein complex and is considered to have low digestibility when fed to animals (Austin *et al.*, 1981). Its intermediate product during hydrolysis, chitobiose is similar to cellulose.

A recent study conducted on 3-week old pullets using exogenous enzyme (Roxazyme G) at 0.05% of the diet, indicated that SWM could successfully replace fishmeal (protein for protein) in practical diets of this class of birds up to point of lay without enzyme supplementation (Fafiolu, 2000). This may mean that egg type chickens are able to utilize SWM better in their rations. However, there is paucity of information on the usefulness of this product for laying birds. This study was therefore designed to assess the potentials of shrimp waste meal in the diets of laying birds.

Materials and Methods

Location.

The experiment was carried out at the Poultry Unit of the College of Animal Science and Livestock Production Farms, University of Agriculture, Abeokuta, Ogun State, Nigeria. The farm is located in the tropical rainforest zone vegetation belt of Nigeria. The prevailing climate is tropical humid.

Shrimp Waste Meal.

Fresh shrimp waste was collected from a shrimp processing industry and was immediately sun-dried. The sun-drying was done by spreading the shrimp waste thinly on a concrete slab for three consecutive days during afternoons / evenings. The length of drying period was about 8hours each day. The resulting dried shrimp waste (10% moisture or less) was ground to pass through 2mm sieve using a hammer mill.

Experimental diets.

Three iso-proteinous and iso-caloric diets were formulated such that a practical layer diet which served as the control diet (diet 1) contained fishmeal (FM) and soyabean meal (SBM) as the major protein sources. In diet 2, the FM ($25gkg^{-1}$) in the control diet was replaced by SWM ($40.4gkg^{-1}$) (protein for protein) while SWM ($201.5gkg^{-1}$)was made to replace SBM ($180gkg^{-1}$) in the control diet (protein for protein) in diet 3 (Table 1).

Experimental birds, design and management.

The birds used for the experiment were 45 week old laying hens of the black Nera strain. They weighed 1.98 $\pm$ 0.13kg on the average at the commencement of the experiment. A total of one hundred and forty-four (144) birds were randomly allocated to the three dietary treatments. The forty-eight (48) birds on each of the three dietary treatments were further divided into four (4) replicates of twelve (12) birds each.

Three (3) birds were housed in each unit of the battery cages equipped with feeders and nipple drinkers. The birds were offered respective experimental diets and water *ad-libitum* and the experiment lasted 10 weeks. The average ambient

Table 1: Gross Composition of Experimental diets (g/kg).

Ingredient	Diet 1 FM/SBM	Diet 2 SWM/SBM	Diet 3 FM/SWM
Maize	420.0	420.0	420.0
Corn bran	150.0	102.4	53.6
Wheat offal	110.5	142.7	185.4
Fishmeal	25.0	-	25.0
Soya bean meal	180.0	180.0	-
Shrimp waste meal	-	40.4	201.5
Bone meal	50.0	50.0	50.0
Oyster shell	55.0	55.0	55.0
Premix*	3.0	3.0	3.0
Salt	3.0	3.0	3.0
Methionine	2 5	2.5	2.5
Lysine	1.0	1.0	1.0
Total	1000.0	1000.00	1000.00
Determined Analysis (g kg^{-1})			
Crude protein	180.0	178.0	175.0
Crude fibre	52.0	58.0	69.0
Fat	42.8	43.8	54.4
Ash	67.5	80.0	145.0
Calculated Analysis (g kg^{-1})			
Crude protein	17.18	17.16	17.18
ME(MJ/kg)	10.75	10.75	10.75
Calcium	35.9	37.4	35.9
Phosphorus	5.0	5.5	5.0
Methione	5.3	5.3	6.8
Lysine	8.5	8.8	10.6

*Supplied per kg ration: Vit. A 1500 I. U.; Vit. E 5mg; Vit. D_3 3000 I. U.; Vit. K 3mg; Vit. B_1 2mg; Vit. B_2 5.5mg; Niacin 25mg; Vit. B_{12} 10ug; choline 120mg; manganese 5.2mg; molybdenums 240mg; zinc 25mg; copper 2.6g; folic acid 2mg; iodine 2mg; D. N. O. T. 60mg; antioxidant 56mg; iron 5g; pantothenic acid 10ug; biotin 30.5g.

termperature in the experimental pen was 32.0 ± 2.0°C.

Parameters Measured.

(i) Performance characteristics determined included hen day production, feed intake and weight change which was the difference in weight of birds at the beginning and at the end of the experiment.

(ii) ***Egg quality characteristics.***
Sampling of eggs: Four (4) eggs per replicate of 12 birds were sampled at

random for 3 consecutive days fortnightly for five times. Each egg was assessed separately for internal and external egg quality traits.

The following external quality traits were determined: egg weight, egg length, egg breadth and egg shape index. Individual egg weight was measured using a sensitive electronic balance while egg length and breadth were measured using a vernier calliper. The egg shape index is a ratio of the length and breadth of the egg.
The interior egg quality traits were measured as follows:

Haugh Unit: A spherometer was used to measure the height of the thick albumen at a mid-point between the inner and outer edges of the thick albumen away from the chalazae. Haugh Unit was calculated using the formula of Haugh (1937) as cited by Stadelman (1977).

Yolk Weight – An egg separator was used to separate the yolk from the albumen. Relative yolk weight was calculated in percentages by relating the yolk weight measured to the nearest gramme to the whole weight of that particular egg and multiplying by 100.

Yolk colour: Yolk colour was scored for individual egg yolk by comparing the colour of the yolks with the colour of the chips of a Hoffman-La-Roche yolk colour fan.
Shell weight: Eggshells airdried over night were weighed and the relative weight calculated by relating the shell weight to the weight of the egg.

Shell thickness: This was measured for individual dry eggshells to the nearest 0.01mm using a micrometer screw gauge.

Albumen weight was calculated by subtracting the yolk and dry shell weights from the whole egg weight. The albumen weight relative to the individual egg weight was calculated.

Chemical Analysis.
The compounded diets and samples of test ingredients, i.e. SWM, FM and SBM were analysed for their proximate composition using the A.O.A.C. (1990) methods.

Statistical Analysis.
The data obtained were subjected to Analysis of Variance (Steel and Torrie, 1980). Duncan's Multiple range test was used to determine the differences between treatment means (Duncans, 1955). When a significant treatment effect was obtained in the analysis of variance, a probability level of < 0.05 was required for a statement of significance.

Results and Discussion

Composition of test-ingredients.
The proximate composition of SWM, FM and SBM used in this study are shown in Table 2. The crude protein values obtained for SWM (402.0 g/kg) is lower than those reported by Fanimo *et. al.* (1996) (47.2%) and Rosenfeld *et. al.* (1997) (50.89%). A number of factors such as variations in proportions of components of the waste, processing and storage of the meal may contribute to these differences. Where the drying is faster and more effective, like the tunnel drying method used by Rosenfeld *et al. (1997)*, the content of crude protein may be higher than where sun-drying was employed. The crude fibre of SWM is higher compared to that of fish meal (8.0%). This could be due to the high proportion of some parts of the shrimp mainly exoskeleton which also reflected in the apparently high ash content. The fat and ash values obtained for SWM are quite moderate and are comparable to those of FM.

Table 2: Proximate composition of test ingredients (g/kg)

	SWM	FM	SBM
Crude protein	402.0	645.0	445.0
Fat	68.0	70.0	56.1
Ash	185.0	200.0	56.0
Crude Fibre	106.0	80.0	53.0
Dry Matter	928.0	910.2	926.0

SWM: Shrimp waste meal
FM : Fish meal
SBM : Soybean meal

The SBM used for this study had a crude protein content of 445.0g/kg. This value is comparable to those of conventional SBM obtained by Bamgbose *et al* (1989). The values of ash obtained for SBM was lower than those obtained for both SWM and FM. However SBM had higher values of crude fibre than FM.

Performance Characteristics.

The average daily feed intake, percentage hen day production, efficiency of egg production (dozen egg per kg feed) and weight change of the experimental birds are presented in Table 3. Hens on the control diet (diet 1) i.e. (FM/SBM) had higher ($P<0.05$) feed intake than the group fed diet 3 (FM/SWM) with about 20% SWM inclusion which had the lowest value. The values

Table 3: Performance of laying hens fed shrimp waste meal-based diets.

Parameters	Diet 1 FM/SBM	Diet 2 SWM/SBM	Diet 3 FM/SWM	SEM	P
Feed intake (g/bird/day)	119.67^{a}	119.03^{a}	100.90^{b}	0.133	0.001
Hen day production, (%)	69.19^{a}	70.29^{a}	40.94^{b}	1.68	0.003
Total egg number	2131^{a}	2165^{a}	1261^{b}	11.29	0.009
Dozen egg per kg feed	0.484^{a}	0.494^{a}	0.334^{b}	0.067	0.006
Body weight change (kg)	0.013	- 0.128	-0.123	0.036	0.056

^{a,b}; Means within the same column with different superscript are significantly different ($P<0.05$).
SWM: Shrimp waste meal
FM : Fish meal
SBM : Soybean meal
SEM : Standard Error of Means

obtained for birds on diet 2 (SWM/SBM) with about 4% SWM inclusion compared favourably with the control (P>0.05).

The fact that there is no significant difference between the control diet and diet 2 showed that SWM successfully replaced fishmeal in the control diet without adverse effect on feed intake. In this study, intake was reduced markedly in diet 3 probably because of the high proportion of the exoskeleton in the feed. This could have caused discomfort for the birds. Fox *et al* (1994) and Talabi (1988) rightly opined that SWM is palatable, acceptable and of pleasant aroma, but this study shows that in spite of the good aroma and palatability, the acceptability of SWM was slightly affected when high levels of SWM was employed.

The percentage hen day production showed significant (P<0.05) differences between diet 3 and the other two diets. It varied from 40.94% - 70.29% and was highest in diet 2 where fishmeal protein was replaced by SWM protein and the SWM inclusion was minimal. The hen day production was depressed (P<0.05) with high level of SWM in the diet, i.e. when the SWM protein was used to replace all the protein supplied by SBM. Many authors have indicted the presence of appreciable level of chitin in SWM as a factor responsible for its low utilization (Austin, *et. al.* 1981; Fanimo *et. al.* 1998). Chitin is a polymer of acetyl-â-D glucosamine linked together by B(1-4) glycosidic linkages. This structure is similar to that of cellulose and it is not likely to be easily utilizable by monogastrics. Although contrary to the deductions above, some authors have reported high level of digestibility of chitin and chitosan when fed to hens and broilers (Hirano, *et. al.* 1990). The issues raised above calls for more studies because evidence from literature and results of this study points to the fact that although palatable and of good aroma, when high levels of sun-dried SWM (Oduguwa *et al.*, 1998) or even oven-dried product (Fanimo *et al.*, 1996) is fed in ration for monogastrics the utilization of that diet will be reduced.

The high hen-day production in diets 1 and 2 indicates that the feed consumed was efficiently utilized for egg production. It is noteworthy that birds on diet 1 had slightly higher but not significant feed intake than those on diet 2 (Table 3). However, birds on diet 2 had a slight edge in terms of egg production over those on diet 1. The egg number followed the same trend as the percentage hen day production.

The efficiency of feed utilization in terms of dozen egg per kg feed showed significant difference (P<0.05) between diet 3 (FM/SWM) and the other two diets and was adversely influenced due to high level of SWM. The reasons adduced earlier are also relevant in this case. The values of efficiency of feed utilization for diet 1 (FM/SBM) and diet 2 (SBM/SWM) were not significantly different (P>0.05). This further implies that SWM can be utilized adequately and successfully replace fishmeal in practical layers' diet with no adverse effect on efficiency of feed utilization.

The loss in weight of birds on diets 2 and 3 is noteworthy. The high level of egg production by birds on diet 2 could also have led to reduction in their weight while the significant reduction in feed intake by birds on diet 3 could have precipitated a weight reduction. There was no mortality throughout the ten weeks of the experimental period even when the SWM was included at high levels. This indicates that SWM did not induce mortality in the laying birds.

Table 4: Egg quality traits of experimental birds.

Parameters	Diet 1 FM/SBM	Diet 2 SWM/SBM	Diet 3 FM/SWM	SEM	P
Egg weight (g)	64.18	65.25[a]	60.07[b]	0.685	0.002
Egg length (mm)	5.53[b]	5.60[a]	5.44[b]	0.137	0.002
Egg breadth (mm)	4.14[a]	4.13[a]	4.03[b]	0.023	0.001
Egg shape index	0.751	0.738	0.741	0.005	0.006
Shell weight %	9.08[b]	9.44[a]	9.45[a]	0.081	0.009
Egg shell thickness (mm)	0.87	0.90	0.88	0.010	0.098
Yolk colour	1.75[c]	9.51[b]	11.30[a]	0.452	0.005
Yolk weight (%)	25.90[a]	24.72[a]	25.65[b]	0.391	0.003
Albumen weight (%)	65.02[a]	65.84[a]	64.9[b]	0.695	0.001
Albumen height (%)	8.75	9.06	8.36	0.204	0.072
Haugh units	90.80	92.45	90.18	1.10	0.083

a, b, c; Means within the same column with different superscript are significantly different (P<0.05).
SWM: Shrimp waste meal
FM : Fish meal
SBM : Soybean meal
SEM : Standard Error of Means

Egg Quality Traits.

External Qualities: Egg weight, egg length and egg breadth decreased (P<0.05) for birds fed the diet with high level of SWM (diet 3) compared with those fed diets 1 and 2 (Table 4). The high values for diets 1 and 2 were a reflection of the high feed intake as well as high efficiency of utilization of the feed consumed. There were no significant (P>0.05) differences in the above traits for birds fed diets 1 and 2. It is therefore deductible that SWM successfully replaced fishmeal in layers diet without any reduction in egg quality with regards to the traits in question. The egg shell weight obtained in diet 2 (SWM/SBM) and diet 3 (SWM/FM) were higher (P<0.05) than the control indicating that the SWM based diets were able to effect a higher deposition of calcium in the shell. SWM actually contained high calcium content. (Table2) which is responsible for eggshell thickness. Fanimo and Oduguwa (1999) reported that SWM had apparently high ash content and is high in calcium and phosphorus. Rosenfeld *et al.* (1997) also indicated that calcium carbonate was responsible for scleratization of the exoskeleton of shrimp and represents most of the mineral matter in SWM. The shell thickness followed the same trend in the three diets although in this case the differences were not significant.

Interior egg quality traits.

There were significant effects (P<0.05) on Hoffman-La-Roche yolk colour fan (RYCF) scores, yolk weight, and albumin weight but no significant (P>0.05) effect on albumen height and the Haugh units (Table 4). Inclusion of SWM in the diets led to marked increases in the RYCF scores due to a corresponding increase in levels of the pink/violet pigment in shrimp exoskeleton. Hens fed diet 3 are expected to have better shell weight as indicated in table 4 due to lower egg production. High levels of Ca and P in SWM may also have contributed to the high shell weight of this group of birds. The higher albumen weight in this study agrees with the findings of Kline *et al.* (1965) who reported an increase in albumen weight and a concomitant decrease in yolk weight as egg weight increased. Similar findings were reported by Cook and Briggs (1977) and Fletcher *et al.* (1981).

Conclusion

Sun-dried SWM at minimal level of inclusion (4%) in diets can be adequately utilized by laying hens and can successfully replace FM in a practical layers diet without adverse effect on the performance and egg quality characteristics. Performance was impaired when SWM was used to replace the protein supplied by SBM in control diet. This was due mainly to the high level of SWM that had to be employed. There is need therefore for graded inclusion of SWM in the diets of laying hens to determine the optimal dietary level.

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